Carotid Endarterectomy Without Indwelling Shunts and Intraoperative Electrophysiologic Monitoring

Kesava Reddy, Michael West and Brian Anderson

ABSTRACT: Although carotid endarterectomy is a common surgical procedure in North America, controversies exist regarding the type of anesthesia, the use of indwelling shunts and the need for intraoperative cerebral monitoring. We present a prospective study of 100 carotid endarterectomies performed over a three year period by a single surgeon without the use of indwelling shunts, patch grafts, or EEG monitoring. The combined stroke and mortality rate was 1%. Our results confirm those of other authors; that indwelling shunts and EEG monitoring are not absolutely essential for a satisfactory outcome in carotid endarterectomies.

RÉSUMÉ: Endartérectomie carotidienne sans mise en place de dérivation à demeure et sans monitorage électrophysiologique peropératoire Quoique l'endartérectomie carotidienne soit une intervention chirurgicale courante en Amérique du nord, le type d'anesthésie, l'utilisation de dérivation à demeure et la nécessité du monitorage cérébral peropératoire demeurent des procédures controversées. Nous présentons une étude prospective de 100 endartérectomies carotidiennes effectuées sur une période de trois ans par le même chirurgien sans mise en place de dérivation à demeure, de greffe ou de monitorage EEG. Le taux combiné d'ictus et de mortalité a été de 1%. Nos résultats confirment ceux d'autres auteurs à savoir que les dérivations à demeure et le monitorage EEG ne sont pas absolument essentiels pour obtenir un résultat satisfaisant dans les endartérectomies carotidiennes.

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Extracranial carotid artery surgery was introduced in 1954.[1] The first carotid endarterectomy was reported by Cooley in 1956.[2] Since then there has been a progressive rise in the popularity of carotid endarterectomy. It has been estimated that there has been a 467% increase in the number of these procedures performed in the United States between 1971 and 1982.[3] Controversy has grown with the popularity of this procedure, as evidenced by the numerous publications on this subject. Foremost amongst the controversies have been the use of intraoperative shunts,[4-14] electrophysiologic monitoring[15-22] and patch grafts.[23,24] Results of the present series of endarterectomies, performed without these adjuncts, support the conclusion of others[5,7-9,12,14] that for a successful outcome, these measures are not absolutely essential.

Materials and Methods

Patient Data

This is a prospective study of 100 consecutive carotid endarterectomies in a total of 89 patients performed in St. Boniface General Hospital over a three year period by a single surgeon (M.W.). Fifty-four patients were male and 35 female. Mean age was 64 years for males and 66 years for females. Fifty-one of the procedures were left-sided and 49 right-sided. Forty-eight patients had carotid bruits appropriate to the side of their symptoms. Twenty-two of these 48 patients had an associated contralateral bruit. Various risk factors in our patients are depicted in Figure 1. All the patients were assigned to Groups I to IV, based on preoperative risk factors, according to the Mayo Clinic Guidelines.[25] The patient distribution amongst these groups is shown in Table 1. Sixty percent of the patients were in Groups III and IV. The mean age, sex distribution, and the risk factors for localized carotid disease in the series is similar to that in other reported series.

Indications for Surgery

Our main indications for carotid endarterectomy were transient cerebral and retinal ischemic episodes, reversible isch-

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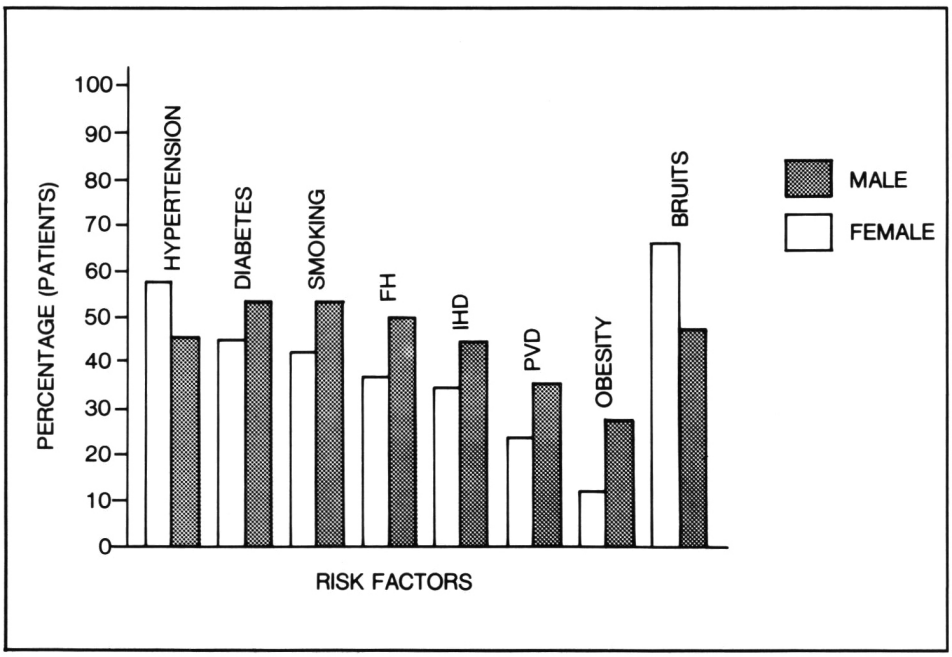

Figure 1 — Preoperative risk factors amongst our patients:
FH = Family history of stroke or ischemic heart disease
PVD = Peripheral vascular disease
IHD = Ischemic heart disease

Table 1: Clinical Grouping (Mayo Clinic Criteria*)

Group	Percentage (of 89 patients)
I	36%
II	4%
III	45%
IV	15%

*GROUP I — Neurologically stable patients with no medical or angiographic risks
GROUP II — Neurologically stable patients with angiographic risks alone
GROUP III — Neurologically stable patients with major medical risks, but no angiographic risks
GROUP IV — Neurologically unstable patients with or without the other risks

emic neurologic deficits, and minor strokes (Table 2). The 5 procedures performed for asymptomatic lesions were for lesions with over 70% stenosis and all these patients had a symptomatic contralateral lesion. Apart from this small group, asymptomatic patients were excluded as surgical candidates, as were the patients with vertebrobasilar symptoms alone, patients with diffuse cerebrovascular disease, and patients with complete internal carotid occlusion.

Angiography

All the patients were studied by transfemoral arch aortography and bilateral selective carotid angiography. The angiographic findings have been grouped according to the degree of stenosis and the presence or absence of ulceration (Table 3), as ulceration has been shown to increase the risk of embolic stroke.[26] Patients with contralateral occlusion or severe stenosis have been grouped separately, as some authors identify this combination as an indication for the use of intraoperative shunts[13] on the premise that these patients are at a higher risk for stroke.

Table 2: Clinical Indications for Surgery

Indication	Percentage of Total Procedures
Transient Ischaemic Attacks & Amaurosis fugax	70%
Reversible Ischaemic Neurologic Deficit	11%
Minor/Recovered Stroke	14%
Asymptomatic	5%

Table 3: Angiographic Indications for Endarterectomy

	Percentage (of 100 Procedures)
Ipsilateral stenosis	
<50%	2
50-75%	19
75-99%	64
Stenosis and Contralateral occlusion/>75% stenosis	3
Ulceration	
<50% narrowing	4
>50% narrowing	8

Perioperative Management

Mild hypervolemic hemodilution was used for all but six of the procedures by transfusing 500 cc. of 5% Albumin over 8-9 hours prior to surgery with a view to improving cerebral perfusion intraoperatively and to prevent potential hypotension during induction of anesthesia. The mean drop in hemoglobin and hematocrit was .20 gm/litre and .056 respectively.

General anaesthesia and standard operative technique were employed with minor variations. Prior to arteriotomy, 0.5 to 1 cc. of 0.1% Xylocaine was injected into the adventitial tissue

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at the bifurcation to obviate intraoperative and early postoperative fluctuations in blood pressure. A bolus injection of 10,000 units of Heparin was given intravenously 5 minutes prior to the arteriotomy. The endarterectomy was accomplished using Loupe magnification without indwelling shunts, vein patch grafts or electrophysiologic monitoring. Normotension or mild hypertension (10-20 Torr above the preoperative mean blood pressure) along with normocarbia, was maintained throughout the procedure. Half the reversal dose of protamine was used immediately after closure of the arteriotomy. The mean clamp time was 28 min. Mean surgical time was 119 min.

Postoperatively the mean arterial pressure was maintained between 80-100 Torr using intravenous diazoxide, nitroprusside or hydralizine to control hypertension, and volume loading or alpha-agonists for hypotension. During the postoperative period, regular evaluations were performed to detect any fresh neurologic deficits and possible regional complications. Patients were discharged within the first postoperative week unless complications had been noted. All patients were advised to take 1300 mg of coated Aspirin daily indefinitely. Routine postoperative angiography was not performed in view of the high risk:benefit ratio. Mean follow-up period was 46 weeks. Three patients were lost to follow-up.

Results

The results were analyzed in terms of minor and major morbidity, major morbidity being defined as that interfering with active daily life. Minor morbidity included complications that had resolved within the follow-up period for each patient, and had not interfered with active daily life (Table 4). There was no mortality in this series. One patient was hemiplegic as a result of a technical error. This procedure was prolonged due to a difficult dissection of a high bifurcation, and an immediate postoperative angiogram revealed an intimal flap. The patient was returned to the operating room and the flap was tacked down immediately. The presumed etiology of the ensuing hemiplegia was embolic and we feel that this would not likely have been averted by the use of an intraoperative shunt. The incidence of persisting postoperative transient ischemic events (occurring mostly in the immediate postoperative period) was 8%, consistent with the reported literature.[11,26,27] Hypertension was more common than hypotension in the immediate postoperative period, in contrast to the experience of others.[28] It is not surprising that all the patients with cardiac complications had underlying atherosclerotic heart disease. The incidence of transient facial (mandibular branch) palsies in our series is somewhat higher than has been reported,[29,30] probably reflecting the number of high bifurcations necessitating retraction at the angle of the jaw. Postoperative wound hematomata were related to raised blood pressure and severe coughing immediately after recovery from anaesthesia. None of the temporary complications prolonged the patients' hospital stay. Though this study was not controlled, we feel the hypervolemic hemodilution may have played a positive role in reducing the morbidity in our series. The overall results of this series of endarterectomies are comparable to those of other authors.[5,14,31,32]

Table 4: Complications of Carotid Endarterectomy

	Percentage of (of 100 Procedures)
Mortality	0%
Major Morbidity	
Operative Stroke	1%
Minor Morbidity	
Persistent Transient Cerebrovascular Events	
Early Transient Ischaemia (Within 30 days of surgery)	7%
Late Transient Ischaemia	1%
Cardiac Complications*	
Angina Pectoris	
Atrial Fibrillation	5%
Heart Block	
Myocardial Infarct	
Other Temporary Complications	
Mandibular Palsy	5%
Wound Hematomas	4%

*All the patients had pre-existent ischaemic heart disease

Discussion

The age and sex distribution and the slight predominance of left-sided procedures in this series is in keeping with the literature. The clinical and angiographic indications for surgery in our series are also similar to those in most other series. Some authors[13] have identified patients with contralateral complete occlusion as a group with a higher risk for stroke and suggest that they benefit from shunting, though this is not universally accepted.[5,33]

Persisting controversies surrounding carotid endarterectomy relate to the type of anaesthetic, the use of intraoperative vascular shunts and vein patch grafts, and the need for intraoperative monitoring of cerebral function. Though local and regional anaesthesia are still popular with some surgeons,[34,35] most recent publications suggest a preference for general anaesthesia.

The use of shunts has been a major point of controversy. With exceptions,[36,37] excellent surgical results have been obtained by groups using shunts routinely,[6,11,27,38] selectively[13,16,31] and not at all.[5,7-9,12,14,15] The proponents of shunts claim they maintain cerebral perfusion, assist in the closure of arteriotomy, and are safe. However, the opponents of shunting point out that only rarely is hypoperfusion the cause of stroke, and that in most cases, strokes are embolic in nature.[20,34,39] Shunts may also increase the risk of intimal flaps, dissection, luminal thrombosis, embolism (due to 'blind' insertion) and sometimes add to the technical difficulty of the procedure. The period of tolerance to cerebral ischemia in humans is unknown. However, occlusion of one middle cerebral artery for up to 2-3 hours has been demonstrated to be tolerated by the subhuman primate.[40,41]

Preoperative trial carotid occlusion (Matas test) has been used as a screening test to predict shunt requirement[34,35] but this test has not been proved to be reliable and also carries a risk of embolic stroke. Intraoperative carotid back flow[42] and stump pressure[43] once used routinely to gauge collateral circulation, have been recently discredited.[21,33,44]

Electroencephalography has been used extensively as a monitoring method,[10,16,20,21] although Ferguson and others found in their experience that EEG is not entirely reliable.[9,15,45,46]

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More recently Ferguson, on the basis of further experience suggests shunting in a select group of patients with EEG and stump pressure changes.[47] Decreased regional cerebral blood flow had been used as an indication for shunting but the exact cut off value has not been agreed upon[16,48] and this is still a novel technique. The use of supraorbital photoplethysmography,[19] cerebral perfusion pressure,[22] and somatosensory evoked potentials[17,18] for monitoring, await systematic and careful evaluation in larger groups of patients.

Patch grafting to improve patency has been carried out routinely in some cases,[5,16,23,24] but has not been conclusively shown to improve the overall results of carotid endarterectomy. The routine use of patch grafts has to be weighed against the possibility of false aneurysm formation though a recent review suggests that the use of patch grafts may not significantly alter the incidence of this complication.[49] The mild hypervolemic hemodilution used in this series may have played some role in optimizing cerebral oxygen delivery. This view is supported by recent evidence in favour of hypervolemic and isovolemic hemodilution in the management of stroke.[50-52]

Conclusions

For carotid endarterectomy to be an acceptable measure for stroke prophylaxis, the mortality and major morbidity of surgery have to be superior to the natural history and medical therapy.[53-57] The beneficial effects of carotid endarterectomy have not been conclusively demonstrated, and at this point await the results of the large multicentre trials being undertaken. Current evidence suggests that cerebral function monitoring, intraoperative shunting and vein patch grafting are not essential to obtain acceptable results. We believe our series and those of others[5,8,9,12,14] confirm this. We also believe that in order to evaluate the results of carotid endarterectomy satisfactorily, the preoperative risk status of patients has to be taken into consideration as the mortality and morbidity vary considerably amongst different risk groups.[25] Careful patient selection along with the exclusion of patients with asymptomatic lesions, diffuse atherosclerotic disease and isolated vertebrobasilar disease as candidates for carotid endarterectomy, along with meticulous surgical technique are of great importance for a successful outcome. Hemorheologic manipulation may have played some positive role in our results.

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